Effects of a Ten-week Aerobic Exercise Training Program on Cardiovascular Variables: Assessed to Predict Change of Blood Pressure in Prehypertensive African American Women

A Thesis

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ABSRTACT

Introduction: One out of four Americans has Hypertension (HTN). Furthermore, HTN is more prevalent in African American women than any segment of the population. Research has shown that blood pressure as low as 115/75 has a positive relationship with an increase risk of cardiovascular disease and doubles the risk with every rise of 20/10 mmHg. Thus, health associations have determined a new category of blood pressure called prehypertension. Aerobic exercise training decreases blood pressure significantly. There are few studies on African American women and how exercise affects blood pressure. The exercise related variables that are of interest include cardiac output (CO), heart rate (HR), total peripheral resistance (TPR), stroke volume (SV), peak volume of oxygen consumption (VO2peak) and blood pressure. Therefore, the purpose of this study is to determine if the changes of the cardiovascular variables that may occur during a ten-week exercise training program can predict a decrease of blood pressure in prehypertensive African American women.

Methods: A total of 12 sedentary women that met the inclusionary criteria were taken through three pre-training visits. These visits include orientation, pre-VO2peak test, and pre-CO2 rebreathing test. Orientations consisted of paperwork explaining confidentiality through HIPPA regulation and inform consent. The VO2peak test was performed on a cycle ergometer using a 2 minute protocol while monitoring with a standard 12-lead ECG system. The third visit consisted of a standard procedure of indirect non-invasive CO2 rebreathing test to determine CO, SV, and TPR. The CO2 rebreathing test was performed

on a cycle ergometer while monitoring with the ECG system. Following testing subjects (n=12) trained for ten weeks three times a week thirty minutes a session at 70% of their VO2peak with increases of intensity every 2 ½ weeks. Once training was completed, the subjects repeated the VO2peak test and CO2 rebreathing test to obtain post values.

Results: Using the SPSS statistical analysis software and a paired sample t-test, I observed that there were not any significant changes from pre-and post-training for HR, SBP, DBP, and MAP. However, there were significant changes ($p<.05$) from pre-to post-training in VO2peak, SV, CO, and TPR. VO2peak increased from19.05 +/- 3.92ml/kg/min to 23.02 +/- 3.92 ml/kg/min. SV increased from 34.17 +/- 11.82 mL to 43.83 +/- 14.03mL. CO increased from 3.12 +/- 0.99 L/min to 3.99 +/- 1.35 L/min. TPR decreased from 35.56 +/- 17.67mmHg*L/min to 27.00 +/- 14.9567mmHg*L/min. Six subjects decreased either SBP or DBP to normotensive values.

Conclusions: Ten-weeks of aerobic exercise training are affective and can elicit changes in the cardiovascular variables of prehypertensive African American women. Uncontrolled factors with the subjects' normal human physiology can cause unwanted changes in the hemodynamics. Therefore, my results may not have demonstrated true training effects and could not be used to make observation of prediction. A revised study will be significant to observe the underlying cardiovascular variables associated with prehypertensive African American women and use exercise as an intervention to decrease the risk of developing full-blown hypertension.

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CHAPTER 1

INTRODUCTION

Background and Prevalence

Hypertension (HTN) is one of the leading causes of death in America. Moreover, HTN estimates an economic cost of 350 billion dollars per year (2). Hypertension, also know as high blood pressure, is defined as chronically elevated high blood pressure with systolic blood pressure (SBP) of 140 mmHg or greater and diastolic blood pressure (DBP) of 90mmHg or greater or taking any antihypertensive medication (2). Hypertension cause problems in the cardiovascular system but it also precipitates into other known diseases. These diseases are stroke, coronary heart disease, heart failure, peripheral arterial disease and renal insufficiency (10). Evidence has shown that with a 5-6 elevation in DBP alone predicts a 35-40% increase risk of stroke and a 20-25% increase of ischemic heart disease (2). Moreover, that approximately 91% of HTN cases precedes the development of Congestive Heart Failure (CHF) and that having high blood pressure increases the risk of developing CHF by two to three times (4). Even blood pressure as low as 115/75 has shown a positive relationship with an increase risk of cardiovascular disease and doubles the risk every rise 20/10 mmHg (10).

As a result of the potential of HTN to precipitate to other disease as well as cause its own cardiovascular concerns there has been research in ways to control high blood pressure. Therefore, two major factors and categories of HTN were determined. HTN was proven to be either (I) a result of the heart pumping with excessive force or (II) the body's smaller blood vessels narrow, so that blood flow exerts more pressure against the vessels' wall (14). Meanwhile as these factors worsen the severity of HTN worsens. Thus, HTN was categorized in four different stages described in Table 1.

Table 1.

Category	Stage	SBP(mmHg)	DBP(mmHg)
Mild	1	140-159	90-99
Moderate	2	160-179	100-109
Severe	3	180-209	110-119
Very severe	4	>210	>120

Depending on the stage of HTN, different types of interventions are used to control the disease. HTN can be controlled by lifestyle modifications and/or antihypertensive drugs. However, as a result of high costs, multiple adverse results and reduce adherence of antihypertensive drugs, lifestyle modifications, specifically exercise, are being of increased interest for high blood pressure treatment (2). With a single bout of endurance exercise blood pressure is reduced up to 22 hours post exercise (10). Several studies have shown that 76% of their HTN population shown a significantly decrease in SBP with exercise training averaging a reduction of 10.6mmHg. Of the same population 81% of HTN subjects showed a significant decrease in DBP with exercise training, averaging a reduction of 8.2mmHg (10). The greatest reduction in blood pressure was among those with the highest baseline values (10). Even the smallest reductions in blood pressure are significant. For this reason, small decrements in SBP and DBP of 3mmHg reduce the risk of stroke by 14% and 17% and coronary artery disease by 9% and 6%.

Since research has shown that small differences in blood pressure can influence the risk of developing cardiovascular diseases, health associations such as the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, have determine a new category of blood pressure called prehypertension. Prehypertension is defined as individuals with a SBP of 120-139 mmHg or DBP of 80-89mmHg (15).This category of prehypertension was introduced to the public health to stress the importance of reducing blood pressure to prevent HTN through healthy lifestyle and interventions so less people can be reliant on medications (10). With this new definition of blood pressure values subcategories were developed to determine appropriate treatments for each stage of prehypertension. The new subcategories are listed in Table 2 below:

Table 2. *Hypertension Classification*

Subcategory	SBP (mmHg)	DBP (mmHg)
Optimal	<120	<80
Normal	120-129	80-84
High normal	130-139	85-89

Common treatments for prehypertension patients usually consist of lifestyle modifications and frequent medical follow-ups (15).

The category for high blood pressure brought up several different questions about its predictability. However, studies have shown that prehypertension (120-139/80-89 mmHg) is a useful predictor of a heightened risk of developing full-blown HTN (15). The relative risk for subjects categorized as normal was twice than the optimal subjects in developing HTN. Moreover, the higher the subcategory the subjects were placed in the higher their risk for developing HTN. For subjects that were classified as high normal their relative risk for developing HTN was tripled the optimal subjects (15). When the subjects were broken up into age groups the age range of 35-44 with high normal blood pressure was four times likely to develop HTN compared with the optimal group at the same age(15). With these findings of the predictive capabilities that prehypertension have for developing HTN a new awareness was developed towards high blood pressure.

As mentioned before, HTN is one of the top ten killers of America. In 2001, one out of five Americans and one out of four adults have HTN (4). However, in 2005 it has been reported that sixty percent of the population has HTN. Unfortunately, thirty percent don't know that they have HTN. Moreover, those that do know that they have HTN, thirty-four percent are on medication and have it controlled, twenty-five percent are on medication but don't have it controlled and eleven percent are not on any medication at all (4). After The Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure report on Prehypertension in 2003, forty-five million people or twenty-two percent of American adults were recognized as having prehypertension.

Hypertension just as any other disease has disparities across different population groups. With gender, men have a higher percentage of prevalence until the age of 55 in which after fifty-five women are higher than men (4). In regards to race, African Americans have a higher prevalence of HTN compared to other races. In 2001, 86.3% of

African Americans showed a prevalence of HTN compared to 61.7% of White Americans and 64.4% of Mexican Americans(4). In which Black female had the highest prevalence of HTN. Out of the population of HTN within the races Black females had 44.7% prevalence compared to 25.5% for White females and 29.9% for Mexican females (4). Due to increase prevalence of HTN, Blacks compared to Whites have a 1.3 times greater rate of nonfatal stroke, 1.8 greater rate of fatal stroke, 1.5 greater rate of heart disease death and a 4.2 times greater rate of end-stage kidney disease(4). As a result of continuously increasing spread of HTN across all racial groups there is continuous research to address the growing disparity among minorities. Therefore, a coalition of federal, private, and professional entities was created to classify, identify and treat, or more preferably, prevent high blood pressure development.

Question

Exercise has shown to be an effective treatment to improve abnormal blood pressure. The changes that occur during aerobic exercise training are known to influence the cardio respiratory system through specific variables. Some cardiac variables that are known to improve due to aerobic exercise training are heart rate, cardiac output, and stroke volume, total peripheral resistance and peak volume of oxygen consumption. In response to the change of cardiac output and total peripheral resistance blood pressure should change since blood pressure is described as cardiac output times total peripheral resistance. The study of human physiology has shown that aerobic exercise training will show improvement at resting levels with TPR, HR, and SV while maintaining resting CO. At peak levels, VO2 will increase after an aerobic training. Therefore, the purpose of this study is to determine if the changes of the cardiovascular variables described above that occur during a ten-week exercise training program can predict a decrease of blood pressure in prehypertensive African American women. .

CHAPTER 2

LITERTURE REVIEW

Cardiac Output

Cardiac output is defined as the volume of blood that is ejected per minute. In hypertension subjects, it is expected to observe low cardiac output values during exercise with the values decreases further below normal as there is an increase in stages of hypertension (7). However, with exercise training, cardiac output is expected to remain the same at sub maximal levels. This was observed with a study of hypertensive and healthy individuals in which both group's CO remained the same after the training (6).

Stroke Volume

Stroke volume is the amount of blood that is ejected with each ventricular depolarization. Hypertension subjects have recorded abnormally low sub-maximal exercise stroke volumes (7). As severity of hypertension increase stroke volume values decreases (7). However, stroke volume is expected to increase with exercise training. Therefore, a trained heart is more efficient and an increase in the amount of blood ejected per beat during the same intensity level should increase. Iwanski's study determined and increase in stroke volume at three, six, nine and twelve months throughout the one year training program(5).

Peak Volume of Oxygen Consumption

Peak volume of oxygen consumption (VO_{2peak}) is used as an accurate measurement of cardio respiratory fitness. Study's has shown a negative correlation of -

.48 between blood pressure and VO_{2peak} (1). Thus with increases of VO_{2peak} there were significantly lower DBP and lower SBP (1). Exercise training increase cardiorespiratiory fitness. Therefore, an increase in fitness will would result in an increase in VO_{2peak}. Iwanski's study showed an increase in VO_{2peak} at three, six, nine and twelve months. A similar study should that chronic training resulted in an increase in VO_{2peak} with subjects with hypertension (11).

Heart Rate

Due to decrease function of the heart in hypertension subjects heart rate increases at resting exercise. Thus the heart rate increases to try to compensate for the hearts inability to supply the body for its demand. Since exercise increases the efficiency of the heart, the heart rate is expected to decrease with training at resting levels. Iwanski's study showed a decrease in resting heart rate at three, six, nine and twelve months in to the study. Heart rate decrease significantly by 6.0 b/min (10).

Total Peripheral Resistance

Total peripheral resistance is determined by the diameter or resistance of the arterioles that the blood flow has to over come (7). In hypertension subjects abnormally high total peripheral resistance during sub maximal exercise is the dominating characteristic (7). At severe hypertension status total peripheral resistance has seen almost triple the normal values (7). Moreover, hypertension Black women are known to have higher total peripheral resistance at rest than White women (12). However, studies have proven to decrease total peripheral resistance through exercise training. Iwanski's study observed a significant decrease in total peripheral study at three, six and nine months (5).

CHAPTER 3

METHODS

Subject description

A total of twelve previously sedentary African American women between the ages of 30-45 years participated in the study. In order to qualify to participate in the study the participants had to meet the following inclusionary criteria: (1) African American woman (2) between the age of 30-45 years, (3) absence of medication that influence blood pressure, (4) sedentary lifestyles, (5) prehypertensive status, (6) non-smokers, (7) body mass index between 25-35 kg/ (m2) and absence of all other known diseases that affect blood pressure. To determine their physical activity the Beacke Physical Activity Questionnaire was used. Blood pressure was taken at the first and second visit for each subject with a standard sphygmomanometer, stethoscope, blood pressure cuff, and mercury pressure gauge. At orientation each subject had the risks, purpose, procedures and confidentiality explained prior to their written informed consent. The participants pre-testing characteristics are presented in Table 3.

Table 3. *Subject Characteristics*

Age (yr)	38.2 +/- 1.5
Weight (kg)	86.9+/- 10.7
Height (in)	65.6 +/- .82
Systolic Blood pressure (mmHg)	126.5 +/- 2.6
Diastolic blood pressure (mmHg)	83.4+/- 1.3
Physical Activity Level	5.88 +/- .27
Body Mass Index (kg/m2)	30.83 +/- 1.1

Peak Volume of Oxygen Consumption Test

A maximal graded exercise test on an electrically braked cycle ergometer (Cybex, Division of Lumex, Ronkonkoma, LI, NY) was used to determine VO_{2peak}. Each participant wore ten electrodes for a standard 12-lead ECG system and Polar heart watch monitor while measuring gases exchange using an open circuit system to assess VO_{2peak}. The participant began the test at twenty-five watts and increase by twenty-five additional watts every two minutes until reached volitional fatigue. Each participant had to maintain a cycle at or above the required pedal cadence of 60 rpm.

CO_2 Rebreathing Test

A noninvasive indirect method of determining mixed venous gas tension was used to determine cardiac output, stroke volume and total peripheral resistance that followed the method described by Jones and Campbell (1982). This test was performed the same electrically braked cycle ergometer previously described above. Each subject wore four chest electrodes and Polar heart watch monitor through out the test. The test consisted of three minutes of seated rest followed by the CO_2 rebreathing procedure. At the end of the rest, blood pressure and heart rate were obtained. The exercise began with a two minute warm-up of 25 watts and then increased to the workload that corresponded to the corresponded calculated 70 % of the subject's VO_{2peak} for three minutes. The CO_2 rebreathing procedure as well as blood pressure and heart rate measurements followed immediately after the exercise portion of the test.

Exercise Training Protocol

The exercise training protocol consisted of thirty minute sessions three days per week. Each participant had followed an individual exercise prescription that was based on the standard equation from the 6th edition of the American College of Sports Medicine Guidelines Resource book. The initial intensity that the subjects began the protocol was 70% of their peak oxygen consumption. The training intensity increased by 5% every two and a half weeks over the ten weeks. A stationary cycle ergometer, air-dyne and/or treadmill were used for the exercise training. Heart rate was monitored using a polar heart watch monitor throughout the session.

Statistical analysis

The changes in hemodynamic variables from pre-aerobic exercise training protocol to post-aerobic exercise training protocol were analyzed using a paired sampled t-test. All descriptive statistics are expressed as means $\pm$ SE. Once the change of variables was accessed then a regression equation was used to identify the predictors of the change of diastolic blood pressure and systolic blood pressure. All statistics were performed using SPSS statistical software (13.0 student version, Prentice-Hall, Inc.). The level of significance was set at $P<0.05$.

CHAPTER 4

RESULTS

We only observed a significant change in pre-training and post-training in four variables. The four variables, which demonstrated this change, were stroke volume (SV), cardiac output (CO), peak volume of oxygen consumption (VO_{2peak}), and total peripheral resistance (TPR). All values of pre- and post-training are given in Table 4. Stoke volume averaged 34.17 +/- 0.34mL for pre-training value and increase to 43.83 +/- 0.41mL post-training. Cardiac output averaged 3.12 +/- 0.29 L/min and increase to 3.99 +/- 0.39 L/min post-training. VO_{2peak} averaged 19.05 +/- 1.13ml/kg/min and increased to 23.02 +/- 1.13ml/kg/min post-training. Total peripheral resistance averaged 35.56 +/- 5.10mmHg*L/min pre-training and decreased to 27.00 +/- 4.32mmHg/L/min at post-training testing. All four variables that changed significantly showed a 20% or above improvement in their post-training values.

Heart rate and blood pressure did not show any significant changes from pre-to post-training. Heart rate averaged 93.35 +/- 4.97 beats/min at pre-training and reduced to 91.47 +/- 2.99 beats/min at post-training. Mean arterial pressure averaged 97.18 +/- 1.87 mmHg and deceased to 92.87 +/- 2.70 mmHg at post-training. Systolic blood pressure average 126.58 +/- 2.64 and decreased to 121.83 +/- 2.59 at post-training. This pattern was also observed in diastolic blood pressure where it averaged 83.42 +/- 1.40mmHg and decreased to 81.75 +/- 2.09mmHg.

Table 4. *Comparison of Pre- and Post-training values*

Variables	Pre-training Mean	Post-training Mean	Sig.(2-tailed)	t
SV (ml)	34.17 +/- 0.34	43.83 +/- 0.41	0.021	-2.68
CO (L/min)	3.12 +/- 0.29	3.99 +/- 0.39	0.042	-2.30
HR (beats/min)	93.35 +/- 4.97	91.47 +/- 2.99	0.675	.430
VO_{2peak} (ml/kg/min)	19.05 +/- 1.13	23.02 +/- 1.13	0.00	-7.68
TPR (mmHg*L/min)	35.56 +/- 5.10	27.00 +/- 4.32	0.00	4.53
MAP (mmHg)	97.18 +/- 1.87	92.87 +/- 2.70	0.11	1.72
SBP (mmHg)	126.58 +/- 2.64	121.83 +/- 2.59	0.14	1.59
DBP (mmHg)	83.42 +/- 1.40	81.75 +/- 2.09	0.430	0.82

Given in Tables 5 and 6 are the resting blood pressure measurements for each subject for both pre and post training. Blood pressure did not change significantly but one subject completely moved from prehypertensive status to normotensive status with both systolic blood pressure and diastolic blood pressure. As given in Table 5 and Table 6, subjects 11 changed her blood pressure from 131/73 to 112/67. Also observed were two subjects that decreased their DBP from prehypertensive values to normotensive values.

The subjects 9 and 12 changed their blood pressure from 138/91 to 130/79 and 138/87 to 124/73. Also there were four subjects that decrease their SBP from prehypertensive values to normotensive values. The subjects 2, 4, 6, and 11 changed their blood pressure from 133/89 to 117/84; 124/83 to 118/80; 121/85 to 113/86; and 131/73 to 112/67. However, there were also five subjects that increase their blood pressure either systolic or diastolic from pre- to post-training. These subjects were 5, 6, 7 ,8, and 10 which their blood pressures changed from 120/86 to 124/91; 121/85 to 113/86; 116/84 to 136/93; 132/80 to 125/87; 132/79 to 133/81.

Table 5. *Pre-training BP measurements*

Subject	Pre SBP	Pre DBP	Pre MAP
01	108	83	91.22
02	133	89	94.47
03	126	81	104.86
04	124	83	95.84
05	120	86	101.89
06	121	85	99.21
07	116	84	97.87
08	132	80	96.48
09	138	91	107.52
10	132	79	98.8
11	131	73	95.47
12	138	87	82.47

Table 6. *Post-training BP measurements*

Subject	Post SBP	Post DBP	Post MAP
01	106	80	81.8
02	117	84	94.89
03	124	80	93.83
04	118	80	89.48
05	124	91	102.53
06	113	86	96.89
07	136	93	107.19
08	125	87	87.43
09	130	79	99.57
10	133	81	98.13
11	112	67	72.88
12	124	73	89.83

Once we performed a paired sample t-test for each variable we put the change of each variable into a regression equation to scrutinize a prediction of the change for MAP, SBP, and DBP. Using a regression linear formula we obtained an equation for MAP, SBP, and DBP. Systolic blood pressure regression equation is: dSBP=-1.195-0.614(dSV)+ 0.261(dTPR)- 0.369(dVO2)-1.088(dRHR) +1.398(dRCO). Diastolic blood pressure regression equation is: dDBP=3.419+ 1.531(dSV) +-0.052(dTPR) -0.059(dVO2) -0.065(dRHR) -1.331(dRCO). Mean arterial blood pressure regression equation is: dMAP=-4.189 +0.867(dSV) +0.800(dTPR) +-0.402(dVO2) +0.334(dRHR) +

0.497(dRCO).. The values of the regression formula are given in Tables 7-9. With the d standing for change of each variable.

Table 7. *Regression Equaiton for systolic Blood pressure*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.466	9.745		.253	.810
	dsv	-1037.569	1464.940	-1.250	-.708	.510
	dtpr	-.514	1.044	-.326	-.492	.643
	dvo2	-.431	2.279	-.075	-.189	.858
	dRHR	-.913	.619	-1.333	-1.475	.200
	dRCO	8.110	13.485	1.033	.601	.574
	dmap	.874	.745	.734	1.173	.294

Table 8. *Regression Equation for diastolic blood pressure*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.419	6.661		.513	.626
	dsv	864.922	1005.995	1.531	.860	.423
	dtpr	-.056	.493	-.052	-.114	.913
	dvo2	-.233	1.267	-.059	-.184	.860
	dRHR	-.030	.434	-.065	-.070	.946
	dRCO	-7.108	9.571	-1.331	-.743	.486

Table 10. *Regression equation for mean arterial pressure*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-4.189	5.057		-.828	.439
	dsv	604.016	763.623	.867	.791	.459
	dtpr	1.059	.374	.800	2.833	.030
	dvo2	-1.949	.962	-.402	-2.027	.089
	dRHR	.192	.330	.334	.583	.581
	dRCO	3.272	7.265	.497	.450	.668

CHAPTER 5

CONCLUSION

The purpose of this study was to use an aerobic exercise-training program to elicit a hemodynamic response and use the change of CO, SV, HR VO2, and TPR to predict a change in blood pressure. Aerobic exercise training has known to affect some of the hemodynamics of the body very rapidly. Many studies have observed a reduction in both diastolic and systolic blood pressure in about 1-10 weeks (3) in individuals with elevated blood pressure. An effective aerobic exercise-training program is expected to improve cardiac variables such as VO2peak, CO, and TPR by 10-20%. A trained individual is expected to have a decrease in resting heart rate and TPR with an increase in stroke volume, and peak volume of oxygen consumption. Due to the changes in SV and HR at rest research says that CO is expected to remain the same. This is because cardiac output is the amount of blood that is supplied to the body with every minute, SV * HR. As a result of the consistency of CO and the decrease in TPR, blood pressure should decrease with an effective aerobic training. With this evidence it would be expected that TPR would be the predictor of the change in blood pressure.

Given in Table 4, the results observed a ($p>0.05$) significant increase in VO2peak (pre-19.05 +/- 1.13ml/kg/min; post- 23.02 +/- 1.13ml/kg/min)which agreed with the current research. The increase demonstrated a 20% improvement that signifies an effective aerobic training program. The increase in VO2peak is likely due to the increase in size and number of mitochondria. This increase in mitochondria increases the mitochondrial protein by two fold and which can generate ATP faster and more efficiently. Therefore, a ten week aerobic exercise program that consisted of 70% of VO2peak three times a week for thirty minutes can improve hemodynamics.

However, even with this effective program there were not any changes in resting heart rate from pre-to post training (pre-93.35 +/- 4.97 beats/min; post- 91.47 +/- 2.99 beats/min)that is observed in other research. Heart rate should have decreased with training while the stroke volume increased to demonstrate a more efficient heart. This observation could have been a result of uncontrolled factors, such as hormonal control. All women were pre-menopausal without being on any type of any oral birth control. Therefore, time and date of their menstrual cycle was not controlled. Different menstrual phases have proved to effect heart rate in different ways. During the ovulatory phase and the luteal phase a significant increase in heart rate was demonstrated compared to the follicular phase. Thus, the non significant change in heart rate may be due to testing on different cycles of time periods of the women's month that was not controlled in relation to their menstruation cycle and were unable to demonstrate true heart rate values (9).

Given in Table 4, SV increased (pre-34.17 +/- 0.34ml; post-43.83 +/- 0.41ml) by 28% after training. This observation was expected with an effective training and agrees with the recent studies on effects of exercise training. An increase SV can be a result of four physiologic factors. These factors are (1) an increase in internal left ventricle volume due to the training-induced plasma volume expansion, (2) reduced cardiac stiffness, (3) increased diastolic filling time and (4) improved intrinsic cardiac contractile function. Thus the heart is functioning more efficiently and is increases the amount of blood ejected with each contraction of the heart.

As a result of this increase in heart rate, CO increased from pre- to post-training (pre-3.12 +/- 0.29 l/min; post-3.99 +/- 0.39l/min). Since normally stroke volume increases at rest and heart rate decrease at rest simultaneously CO would remain the same. However, since heart rate remained the same with increases in stroke volume the CO results do not agree with recent studies.

As well as the improvement in VO2peak, TPR decreased significantly ($p>0.05$) with training from 35.56 +/- 5.10 mmHg*L/min to 27.00 +/- 4.32 mmHg*L/min. Total peripheral resistance revealed a 24% decrease. This improvement of TPR concurs with the recent research suggesting that a 20% improvement is noted after an effective training program due to better blood flow distribution. .

The results given in Table 4, blood pressure did not change with the ten-week aerobic training program. Mean arterial blood pressure stayed constant as well as systolic blood pressure and diastolic blood pressure. Blood pressure is the amount pressure that is exerted against the walls of the arteries. This is expressed as MAP = CO X TPR. Therefore blood pressure is dependent on the cardiovascular variables, cardiac output and total peripheral resistance. Therefore a decrease in blood pressure would be due to a decrease in CO, TPR or both. The results revealed a significant decrease in TPR as well as a significant increase in CO. Therefore, blood pressure did not change from pre-to post training even with and effective aerobic exercise program.

Given that there was not a change in blood pressure with the training program the regression formula did not show a significant ($p>0.05$) regression equation. Therefore, there was not any evidence of a variable to predict a change in blood pressure.

Some limitations of the study were that were schedule accommodations. The majority of the women had full-time jobs as well as family obligations. This was difficult to get the subjects to schedule tests and exercise sessions. It was difficult to insure adherence to all rules and regulation of the study. This was due to the unfamiliarity of exercise regimens and other obligations.

The results of this study has shown that exercise can result is beneficial in prehypertensive African American women. However, it could not answer the question seeked. However, with control of menstruation a future study may demonstrate a decrease in blood pressure and then a prediction may be observed. Since the expected variables increase accordingly to the recent studies. The elements of the training program are not needed to be modified. Nonetheless, a larger population study would give more significance to the findings and even with variability in menstruation cycles could show a significant change in blood pressure.

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